

Distribution of *Orientogalba viridis* (Quoy & Gaimard, 1832) (Gastropoda: Lymnaeidae), the snail intermediate host of *Fasciola hepatica* Linnaeus, 1758, in Papua New Guinea

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Abstract: In surveys carried out to determine the distribution of *Orientogalba viridis* (Quoy et Gaimard, 1832) in rivers of mainland Papua New Guinea, the snail was found only at altitudes above about 600 metres where temperatures below 25° to 26°C enabled the snail to reproduce. It was common in the Lamari, Asaro and Wahgi rivers that drain the highland provinces of Eastern Highlands, Simbu and Jiwaka, and in a part of Morobe Province drained by the Watut River. Its distribution elsewhere was sporadic, being found at isolated sites in other parts of Morobe Province, and in Western and Central provinces. The snail was not present in streams of Western Highlands, Enga, Hela, Sandaun or Southern Highlands provinces. Animal infection with the liver fluke, *Fasciola hepatica*, was common where the snail had a long-established contact with infected cattle and sheep. Local conditions in the Ramu River valley led to snails being present at an elevation below 600 meters and infection of cattle with liver fluke, while unknown factors limit the presence of the snail in the upper reaches of the Wahgi River.

Key words: Host, parasites, cattle, sheep, surveys, river systems, Papua New Guinea.

Introduction

Interest in the distribution of the semi-aquatic snail, *Orientogalba viridis* (Quoy et Gaimard 1832) in Papua New Guinea (further in text – PNG) lies in its role as intermediate host of the digenetic trematode, *Fasciola hepatica* Linnaeus, 1758, the liver fluke of herbivorous mammals and humans. Ruminants were unknown in PNG until the late 19th century when cattle were imported to coastal plantations and some sheep and goats into upland areas. The majority of the animals were killed during World War 2 (WW2) (Anderson 1962). There are no authentic records of *F. hepatica* being present in the country before WW2, but staff at the Catholic Mission at Fane, Central Province, when enquiries were made in the 1970s, said that liver fluke was seen in sheep at Ononge Mission prior to the war. The sheep had been imported from eastern Australia.

In 1949 attempts were made to establish sheep from Australia at Nondugl, a highland site

in the then Western Highlands District, now in Jiwaka Province (Anderson 1972). They were soon found to be carrying *F. hepatica* which, due to the presence of the snail intermediate host, became a well-established disease. This, together with other issues, led to the abandonment of the enterprise in 1962 (Anderson 1972) and led to the decline of the pioneer sheep industry (Talbot 1972).

The PNG administration realised that before another attempt was made at establishing a sheep industry, more information was needed about the snail intermediate host. A preliminary survey carried out in 1964 by the second author (J.C.B.) to assess the extent of the snail's distribution showed that the snail was not found below about 600 metres. The disease of fascioliasis, therefore, would be a highland problem. Experimental work on the PNG snail in Australia found it was a relatively efficient host of *F. hepatica* but that it was unable to reproduce at temperatures above 25° to 26°C, although able to survive temporarily in temperatures up to 35°C (Boray 1964; 1978).



Up to this time, the PNG snail (Fig. 1) was regarded as being the same species as occurred in eastern Australia, *Lymnaea tomentosa* (L. Pfeiffer, 1855) – now placed in the genus *Austropeplea* Cotton, 1942. Later, the PNG snail was shown to be a separate species, *L. viridis* Quoy et Gaimard, 1832, common in east Asian and Pacific countries (Boray 1978; 1982), and was subsequently placed in the genus *Austropeplea*. Classification of lymnaeid snails, however, has been problematic (Puslednik et al. 2009), being based largely on morphological features. Recently, a clearer relationship has been established within the lymnaeids by means of molecular taxonomic studies (Aksenova et al. 2018) which place the PNG snail in the genus *Orientogalba* Kruglov in Kruglov et Starobogatov, 1985 as *O. viridis* (Quoy et Gaimard, 1832) (Aksenova et al. 2018; Vinarski et al. 2020).

In 1975 the government established a sheep farm at Menifo, Eastern Highlands Province, to serve as a distribution centre for village-based sheep projects. It became apparent that liver fluke was a problem at the farm as well as in many of the projects. There was a need for more information on the distribution of the snail.

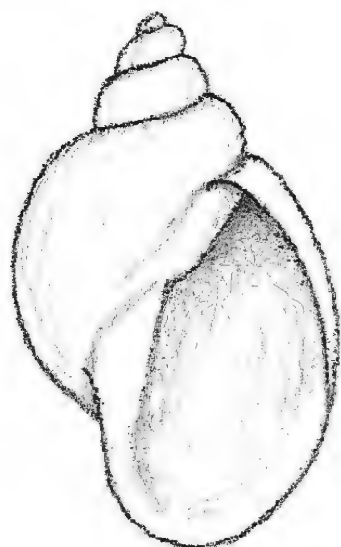


Figure 1. *Orientogalba viridis* (Quoy et Gaimard, 1832) shell (height 10 mm) from Menyamya, Morobe Province, Papua New Guinea, apertural view (schematic).

Material and methods

Surveys of rivers in mainland PNG were carried out over many years (Fig. 2). They focused on parts of the highlands where cattle or sheep were present or where there was potential for establishing projects. Examination centred mainly on shallow

margins of streams and creeks, seepages, drains and swampy ground, the favoured habitats of the snail. The altitude, hydrogen ion concentration (pH) and temperature of water were recorded for most sites. Snails were collected and stored in 10 percent formal saline and sent to the late Dr Boray in Australia for identification. Information on the presence of *F. hepatica* in animals is based on data contained in Annual Reports of the Department of Agriculture, Stock and Fisheries, later Department of Primary Industry, abattoir reports, National Veterinary Laboratory records and field trials (Owen 1984; 1989).

Results

Although *O. viridis* was reported to prefer fast-running streams and deep water of rocky creeks to shallow aquatic habitats in PNG (Boray 1969), this was not experienced during the current surveys. Its presence at a site, however, could vary over time; it might be common on one visit but absent on another, the result, possibly, of flash-flooding. This could mean the presence of the snail was missed in some locations where only one or two sites were examined on a single occasion.

Spatial distribution of *O. viridis* was discontinuous (Table 1). It was widespread in the eastern part of the central highlands, comprising of Eastern Highlands, Simbu and Jiwaka provinces, drained by branches of the Lamari, Asaro and Wahgi rivers that eventually join the south-flowing Purari River. The snail was common also in that part of Eastern Highlands Province drained by headwaters of the Ramu River, that flows north, and the Wanton River that flows east to join the Markham River in Morobe Province. A limit in the distribution of the snail was found in the valley of the Wahgi River in the Minj / Banz area, Jiwaka Province. Extensive examination upstream and to the immediate west of sites in Malenban, Fatima and Kurumul properties, failed to find the snail. It is absent, therefore, from the upper reaches of the Wahgi River that drains much of Western Highlands Province.

No snails were found near the source of the Sepik River at Telefomin or in the headwaters of its tributaries, the Lai, Baiyer and Trauna rivers. The snail was absent from waters of the south-flowing Kikori and Erave rivers. An early report of *O. viridis* occurring in the Kagua area of Southern Highlands Province, drained by the Erave River, is considered to be a case of mis-identification as extensive



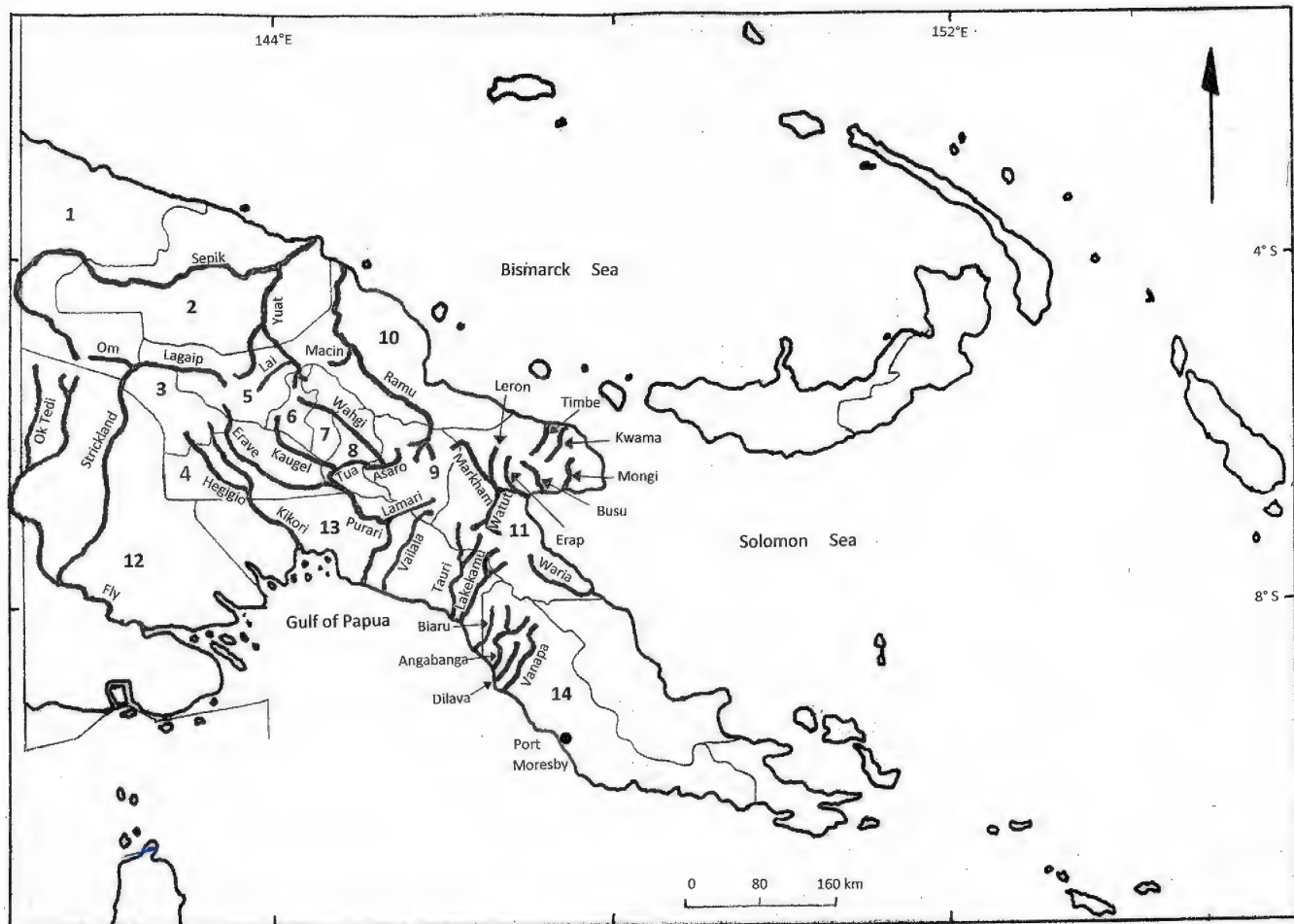


Figure 2. Map of the River Systems of mainland Papua New Guinea whose headwaters were examined for the presence of the snail, *Orientogalba viridis* (Quoy et Gaimard, 1832).

Legends: PNG provinces: 1 – Sandaun; 2 – East Sepik; 3 – Southern Highlands; 4 – Hela; 5 – Enga; 6 – Western Highlands; 7 – Jiwaka; 8 – Simbu; 9 – Eastern Highlands; 10 – Madang; 11 – Morobe; 12 – Western; 13 – Gulf; 14 – Central.

searches of the area at different times failed to find the snail. Hela, Enga and Southern Highlands provinces, therefore, do not have the snail.

The only record of *O. viridis* in the Fly / Strickland river system of Western Province was at Bultem village near the source of Ok Tedi that drains the southern slopes of the Star Mountains. The Tauri River at Menyamyia was the only river of those that enter the Gulf of Papua to the east of the Purari, to have the snail. *Orientogalba viridis* was common in Morobe Province, in branches of the Watut River, a southern tributary of the Markham River. It was found also at Wantoat on the Leron River, a northern tributary of the Markham River, but present only in the Kwama River at Kabwum of the fast-flowing streams of the Huon Peninsula.

Records of cattle slaughtered at a highland abattoir in the 1970s showed that 100 percent of livers of animals originating from both large and small projects in the eastern part of the central highlands were condemned due to fascioliasis. The records also revealed that cattle born and bred at two sites, Gusap and Dumpu, located at elevations below where the snail would be expected to occur, were infected with liver fluke. Examination of sites at the two farms discovered the snail in a shallow backwater of the main Ramu River at Gusap (altitude 432 m) (see location in Fig. 3). Examination of small streams and creeks in the vicinity of both Gusap and Dumpu failed to find other examples of the snail.



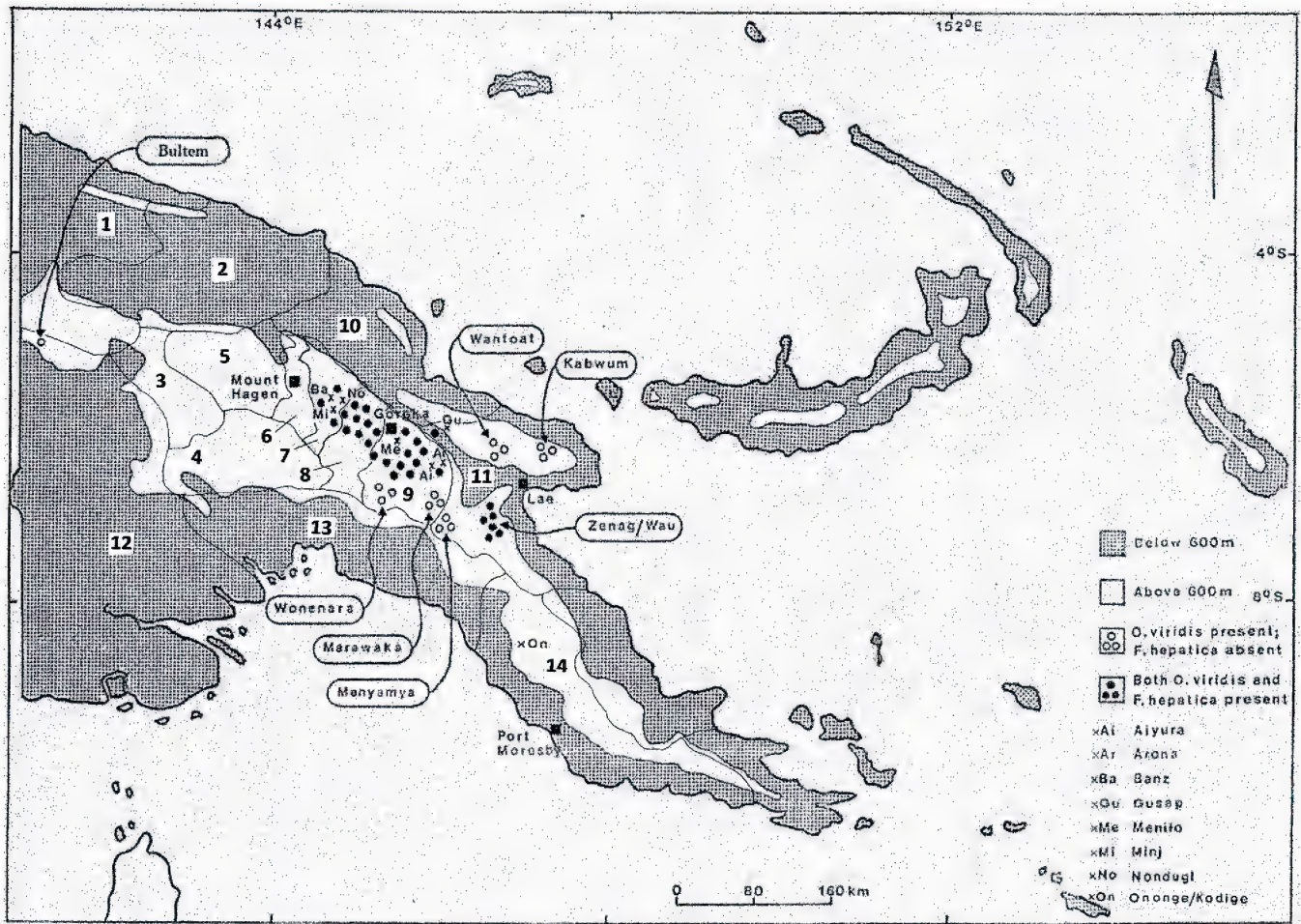


Figure 3. Map showing the distribution of the snail, *Orientogalba viridis* (Quoy et Gaimard, 1832), and the digenetic trematode, *Fasciola hepatica* Linnaeus, 1758 in mainland Papua New Guinea. Provinces are numbered as in fig. 2.

Table 1. River systems and locations in mainland Papua New Guinea examined for the presence of the snail *Orientogalba viridis* (Quoy et Gaimard, 1832).
Legends: + = present; - = none seen / not present; nd = no data; * = sites visited twice or more times.

Main River	Main tributaries	River(s) or creek(s) into which sites drain	Locality	Province	No. of sites examined (No. with <i>A. viridis</i>)	Altitude, m (approx.)	pH of water	Water temp., °C	<i>Orien-togalba viridis</i>	Other molluscs (provisional identification)
Markham	Wanton	Wanton	Omaura, Arau	Eastern Highlands	6* (6)	1405	7.0-7.6	21.0-23.0	+	<i>Physastra</i> sp., <i>Planorbinae</i> spp.
Markham	Watut	Isano / Langimar	Sites between Menyamya & Aseki	Morobe	4	1153-1263	6.0-7.6	18.0-20.0	-	<i>Physastra</i> sp.
Markham	Watut	Snake / Watut	Zenag, Mumeng	Morobe	14* (4)	525-1156	6.9-7.5	19.0-30.8	+	<i>Physastra</i> sp., <i>Planorbinae</i> sp., <i>Thiara</i> sp.
Markham	Watut	Bulolo	Wau, Bulolo	Morobe	21* (1)	660-1200	6.4-7.4	14.6-25.0	+	<i>Physastra</i> sp., <i>Thiara</i> sp.
Markham	Leron	Leron	Wantoat	Morobe	11(6)	1050-1186	7.5-8.0	19.8-22.5	+	<i>Physastra</i> sp., <i>Thiara</i> sp., <i>Potamopyrgus</i> sp.
Markham	Erap	Selep	Kisengan	Morobe	5	1518	7.5-8.5	20.0-21.0	-	<i>Physastra</i> sp., <i>Thiara</i> sp., <i>Potamopyrgus</i> sp.
Markham	Markham	Markham	Waterais, Utwun Creeks	Morobe	13	441	7.2-7.6	23.5-27.2	-	<i>Physastra</i> sp., <i>Thiara</i> sp., <i>Gabbia</i> sp.
Mongi	Bulum	Bulum	Pindiu, Mindik	Morobe	13	720-1281	7.4-7.6	20.5	-	<i>Physastra</i> sp., <i>Thiara</i> sp.
Kwama	Pumune	Usugem	Kabwum, Tipsit	Morobe	14 (4)	1072-1547	7.5-8.0	17.5-21.0	+	<i>Physastra</i> sp., <i>Planorbinae</i> sp., <i>Succineidae</i> spp.



Table 1 (continuation)

Timbe	Timbe	Timbe	Derim, Huruk	Morobe	5	1412-1480	8.0-8.5	15.5-21.5	-	<i>Physastra</i> sp., <i>Planorbinae</i> sp.
Busu	Busu	Busu	Boana	Morobe	6*	575-909	7.5-8.5	19.0-22.5	-	<i>Thiara</i> sp., <i>Planorbinae</i> sp., <i>Potamopyrgus</i> sp.
Waria	Waria	Bu-Bu	Garaina	Morobe	19	598-767	5.0-6.0	20.6-27.0	-	<i>Bullastra lessoni</i>
Ramu	Ramu	Buru / Gusap	Gusap	Morobe	15* (1)	432-450	7.5-7.6	23.7-32.5	+	<i>Physastra</i> sp. <i>Thiara</i> sp.
Ramu	Ramu	Faria / Bumpu	Dumpu	Madang	7	280-580	6.5	25.0-31.0	-	<i>Thiara</i> sp.
Ramu	Ramu	Macin	Simbai	Madang	4	1880	nd	nd	-	<i>Physastra</i> sp.
Ramu	Ramu	Mamalain	Arona, Kas-sam	Eastern Highlands	4 (3)	1321-1350	7.0-8.5	18.0-24.0	+	
Ramu	Ramu	Ramu	Kainantu, Aiyura	Eastern Highlands	7 (7)	1575-1734	6.5-8.5	18.0-23.2	+	<i>Physastra</i> sp., <i>Planorbinae</i> sp.
Ramu	Ramu	Ramu	Kainantu, Unantu	Eastern Highlands	5 (1)	1661-1680	6.5-7.0	21.0-22.0	+	
Ramu	Pomasi	Wara Kora	Bilimoia	Eastern Highlands	1	1839	6.8	16.4	-	
Purari	Aure	Lamari	Barabuna, Obura	Eastern Highlands	5 (3)	1720-2452	7.2-7.4	17.4-22.0	+	<i>Physastra</i> sp.
Purari	Lamari	Puburamba	Okapa, Yagusa, Lufa	Eastern Highlands	7 (4)	1403-1957	7.5-8.0	15.4-31.5	+	<i>Physastra</i> sp.
Purari	Dunantina	Ortowat	Sonofi, Fomu	Eastern Highlands	3 (2)	1635-1853	7.2-8.0	16.2-19.2	+	
Purari	Lamari	Aziana / Imani	Wonenara	Eastern Highlands	2 (1)	1537	nd	nd	+	<i>Physastra</i> sp., ? <i>Physa</i> sp.
Purari	Wahgi/Tua	Dunantina	Goroka, Henganofi	Eastern Highlands	4 (3)	1660-1848	7.5-8.0	19.0-25.4	+	
Purari	Wahgi/Tua	Mai	Warabung, Chuave	Simbu	3 (3)	1891	7.4-8.5	23.2-31.4	+	<i>Physastra</i> sp.
Purari	Wahgi/Tua	Simbu	Kundiawa, Gembogl	Simbu	2 (2)	1772-1965	7.6	19.5-20.0	+	<i>Physastra</i> sp.
Purari	Wahgi/Tua	Wahgi	Kundiawa, Gumine	Simbu	6 (3)	1732-1911	6.5-7.5	20.0-23.5	+	<i>Physastra</i> sp.
Purari	Tua	Sena	Karimui	Simbu	13*	837-1067	6.0-7.0	20.0-22.0	-	<i>Planorbinae</i> sp., limpets (<i>Pettancylus</i> or <i>Ferrissia</i> sp.)
Purari	Wahgi/Tua	Wahgi	Kundiawa, Miunde, Kup	Simbu	7 (2)	1518-1788	7.0-7.3	25.0-26.0	+	
Purari	Wahgi/Tua	Minj/Kimil	Minj/Banz area	Jiwaka	30* (10)	1603-1607	6.0-7.3	19.0-25.0	+	<i>Physastra</i> sp.
Purari	Wahgi/Tua	Aiba	Nondugl, Kudjip, Kind-ing	Jiwaka	6*(2)	1588-1676	6.0-7.0	22.6-28.5	+	<i>Physastra</i> sp.
Purari	Wahgi/Tua	Minj	Tombil, Kugark	Jiwaka	19 *(4)	1560-1570	6.5-7.5	19.0-25.5	+	<i>Physastra</i> sp.
Purari	Wahgi/Tua	Kilip	Kurumul Fatima, Banz, Kilip, Kempis	Jiwaka	18* (7)	1550-1603	6.5-7.4	19.2-30.0	+	limpets (<i>Pettancylus</i> or <i>Ferrissia</i> sp.)
Purari	Wahgi/Tua	Kimil	Aviamp, Kobam, CLTC	Jiwaka	6*	1550-1589	5.6-6.6	20.0-22.0	-	<i>Physastra</i> sp.
Purari	Wahgi/Tua	Gumants / Kum / Kuman	Mt Hagen, Mt Ambra, Gumants	Western Highlands	40*	1591 - 1818	6.0 -7.5	18.0 -29.0	-	<i>Physastra</i> sp., <i>Thiara</i> sp.
Purari	Erave	Ka	Kandep, Longap, Marient Valley	Enga	14	2402-2483	6.0-8.0	15.4-28.4	-	<i>Physastra</i> sp., <i>Bullastra lessoni</i>
Purari	Erave	Erave	Nipa area	Southern Highlands	9	1865	5.5-8.5	17.0-33.5	-	<i>Physastra</i> sp.
Purari	Erave	Kombia / Kalpa / Mendi	Mendi area, Poroma	Southern Highlands	16*	1495-1867	5.5-8.5	12.5-31.0	-	<i>Physastra</i> sp.
Purari	Erave	Erave	Erave	Southern Highlands	2	1096	6.0-6.5	23.5-24.5	-	
Purari	Erave	Nembi	Kagua area, Sugu	Southern Highlands	16*	1617	5.5-7.6	19.0-34.5	-	<i>Physa</i> sp.
Purari	Iaro	Iaro	Ialibu area	Southern Highlands	9	2061	5.5-6.5	16.0-20.0	-	<i>Physastra</i> sp.
Purari	Tua/Erave	Nama / Poru	Pangia	Southern Highlands	6	1624	6.5-7.0	20.0-23.5	-	<i>Physastra</i> sp.
Purari	Tua	Nebylier / Kaugel	Togoba, Tomba	Western Highlands	4	2567	6.0-7.2	11.5-24.5	-	



Table 1 (continuation)

Sepik	Yuat	Lai / Baiyer / Trauna	Baiyer, Trauna	Western Highlands	9	1206	6.5-7.4	18.5-28.0	-	<i>Physastra</i> sp., Planorbinae sp.
Sepik	Yuat	Lai	Wapenamanda, Tsak Valley, Sopas	Enga	5	1728-2217	6.0-7.4	17.2-31.0	-	<i>Physastra</i> sp.
Sepik	Yuat	Ambun / Lai	Kompam, Par	Enga	2	1550-2036	7.0-8.0	22.0-22.4	-	<i>Physastra</i> sp.
Sepik	Yuat	Lai	Sirunki	Enga	2	2396	7.0-8.0	22.0-22.4	-	<i>Physastra</i> sp.
Sepik	Sepik	Sol	Telefomin	Sandaun	3	1508	5.0-6.0	19.5-27.5	-	<i>Physastra</i> sp.
Fly	Strickland	Langi / Lagaip	Laiagam area	Enga	4	2274	6.5-7.0	13.0-25.2	-	<i>Physastra</i> sp.
Fly	Strickland	Porgera / Lagaip	Porgera	Enga	1	2248	7.4	16.0	-	<i>Physastra</i> sp. Planorbinae sp.
Fly	Strickland	Logaiyu / Tumbudu / Lagaip	Lake Kopiago	Hela	3	1380	7.4	19.6	-	<i>Physastra</i> sp.
Fly	Strickland	Ok Tedi	Bultem vil-lage	Western	2* (1)	650	nd	nd	+	
Kikori	Mubi	Waga / Marumba	Margarima area	Hela	10	2200-2666	5.6-7.0	14.2-26.0	-	<i>Physastra</i> sp.,
Kikori	Kikori	Mubi	Pimaga	Southern Highlands	5	1209	5.5-6.5	22.5-28.0	-	<i>Physastra</i> sp.
Kikori	Hegigio	Tagari	Tari	Hela	4	1608	5.5-6.5	22.0-30.0	-	
Kikori	Hegigio	Naggia / Tagari	Koroba	Hela	1	1735	6.0	19.0	-	<i>Physastra</i> sp., bivalves
Kikori	Hegigio	Tagari	Komo	Hela	2	1528	6.0-6.5	22.5	-	
Tauri	Tauri	Kapau	Aseki	Morobe	16	1240-1263	6.0-7.5	17.5-22.5	-	<i>Physastra</i> sp.
Tauri	Tauri	Tauri	Menyamy, Concordia	Morobe	9* (6)	1153	6.8-7.3	20.6-28.0	+	<i>Physastra</i> sp., Planorbinae sp.
Tauri	Wa	Bema	Kaintiba, Bema, Kana-bea	Gulf	14	635-1320	6.0-7.4	19.0-21.5	-	
Vailala	Tuoa	Yaiga	Marawaka	Eastern Highlands	6 (6)	1835	7.2-8.5	16.0-28.5	+	<i>Physastra</i> sp., Planorbinae sp.
Ang-abanga	Loloipa	Ivane / Loloipa / Aiwara	Tapini, Erume, Kerau, Kosipe	Central	27*	750-1959	7.0-7.6	15.0-21.0	-	<i>Physastra</i> sp., <i>Thiara</i> sp., ? <i>Physa</i> sp.
Ang-abanga	Ane	Mas	Fane, Belav-ista	Central	13	1099-1464	7.2-7.6	nd	-	<i>Physastra</i> sp.
Lakeka-mu	Kunimaipa	Zokatai / Kunimaipa	Guari, Kamulai, Zailipu	Central	25	1768-2063	6.0-7.3	15.5-22.0	-	<i>Physastra</i> sp.
Biaru	Biaru	Tapala	Olivi, Jonol, Ue, Guari-maipa	Central	30	1629	6.6-7.2	19.0-24.5	-	
Dilava (Kubuna)	Tefe	Tefe	Kodige, Avele, Iride	Central	21	792-1362	5.6-7.2	nd	-	<i>Physastra</i> sp., <i>Thiara</i> sp.
Vanapa	Udava	Moia	Woitape, Ononge	Central	18	1632-1694	7.2-7.6	nd	-	<i>Physastra</i> sp.

Discussion

As PNG is a tropical country and temperatures suitable for *O. viridis* to reproduce are found only in the highlands, the only possible explanation for the presence of the snail at Gusap, is that it is transported downstream in waters of the Ramu River from its normal habitat at more than 1260 m in Eastern Highlands Province, to an altitude of 441 m on the main valley floor. Flash-flooding, that occurs in the highlands, can remove alluvial mud, and the snails, leading to passive migration and introducing snails into new environments (Boray 1969). Snails are known also to float and drift with currents for long distances (Boray 1963).

The temperature of the Ramu River after its rapid descent from 1260 m at Yonki to 441 m at the main valley floor was 23°C, while 10 km

downstream the mid-morning water temperature in the shallow Gusap backwater, was 25°C under shade and 27°C in the open. Water temperature of small creeks flowing into the Ramu River at both Gusap and Dumpu had a range of 26°C to 32°C; none carried *O. viridis*. The presence of empty *O. viridis* shells attached to shaded sides of rocks out of the water at Gusap suggests an environment not conducive to survival. Nevertheless, as cattle at Gusap and nearby Dumpu can be infected with liver fluke, the snail is able to survive and have the opportunity to liberate the parasite's metacercariae on to pasture. A high proportion of metacercariae are viable and infective for 36 days at +25°C and for 14 days at +30°C (Boray 1969). Cattle could also become infected while drinking; Morley (2015) states that floating metacercariae, buoyed by small trapped air bubbles, may have an



important epidemiological role particularly under still or stagnant water conditions, as might occur in a backwater.

An explanation remains to be found why *O. viridis* does not occur further upstream in the Wahgi River beyond the Minj / Banz area of Jiwaka Province. The situation has not changed since monitoring of the area began. There are no physical barriers and the pH levels and the temperature range are similar on either side of the Minj / Banz boundary. It is possible that waters of the upper Wahgi River in Western Highlands Province contain mineral elements that inhibit migration of the snail upstream.

Experimental work conducted in Australia found the host-parasite relationship between *O. viridis* from PNG and the Australian strain of *F. hepatica* was less well adapted when compared with the taxon *Austropeplea tomentosa* (L. Pfeiffer, 1855) and the fluke (Boray 1978). Infection was found to curtail the growth of the PNG snail from the normal size of 10–12 mm to 7 mm, under experimental conditions (Boray 1978). However, the relationship is sufficiently well adapted under field conditions in PNG for pasture to be contaminated with enough larvae for cattle, known to have greater resistance against *F. hepatica* than sheep (Boray 1969; Rickard & Howell 1982), to become heavily infected, as seen from abattoir records and field trials (Owen 1984). Preventing the spread of *F. hepatica* beyond its current distribution (Fig. 3) necessitates selecting animals only from fluke-free locations for distribution to sites such as Menyamya, where the snail occurs. Treatment of fluke-infected animals with a course of fasciolicide before movement is, under PNG conditions, a less certain way of ensuring transferred animals are free of the fluke.

No animals at Ononge Mission (Vanapa River system), Central Province (Fig. 3), have been found infected with *F. hepatica* after WW2, but unconfirmed reports in later years of infected cattle from nearby Kodige (Dilava River system) in the Fane area of the province, where *O. viridis* was not found, are unresolved, and the provenance of the animals could not be fully ascertained.

There are no records of humans or of goats, pigs and other susceptible animals in PNG, being infected with liver fluke.

Bullastra lessoni (Deshayes, 1830), another lymnaeid snail encountered in the surveys, is an unsuitable intermediate host for *F. hepatica* (Boray 1978).

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